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Indian Space Programme – Touching Lives

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Abstract

The Indian Space Programme has deployed space-based applications in a variety of fields, including communications, remote sensing, cartography, television broadcasting, disaster management and telemedicine, benefiting all sections of the society. The space programme has also built synergy in industrial development in the country. A number of technologies developed have been transferred to Indian industries. In addition, a significant number of technology spin-offs have lead to applications of societal benefit, in areas unconnected with the Space Programme. Artificial Polyurethane (PU) foot, Fire extinguishing powders, PARAS 3D software (Parallel aerodynamic simulator) for Computational Fluid Dynamics simulation with parallel computing, Liquid Level Sensor and Silica Cloth are some examples. The paper briefly describes some of these important developments which have been able to find applications offering significant benefits to the society. Thus the Space Programme has been able to touch the lives of the common Indian in myriad ways.

Keywords

ISRO, spin-offs, technology transfer, tele-education, radar, poly-urethene, navigation, GAGAN.

1.0 Introduction

The Indian Space Programme was initiated more than five decades ago, with the primary objective of utilizing space technology for socio-economic development of the country. Since then, it has achieved many milestones, from launching sounding rockets to exploring Mars [5]. A large number of satellites have been deployed into orbit and a number of space-based applications have been built using them. These applications help percolate the benefits of space technology to the lives of the common man in a number of ways, viz. in the areas of communications, remote sensing, agriculture, fisheries, cartography, television broadcasting, disaster management, tele-education and telemedicine. In addition to this, there have also been other facets in the influence Space Programme has been able to make in the society. The contribution of Indian Space Programme to the growth of industries in the country is notable. Certain 'spin-off's of space technology abound in our daily life as little gadgets or techniques that make our lives a lot simpler and which had their origins in ideas intended not for general usage. The body-hugging form of a car seat is typical of how space science has enhanced our comfort levels while driving. The seats were originally designed for NASA spacecraft based on the natural posture a human body assumes in a micro-gravity environment. There are many similar spin-offs from the Indian Space Programme that have touched the life of the common man. A few of these are highlighted in this paper.

2.0 Industry participation

Indian Space Research Organisation (ISRO) has always laid emphasis on development of indigenous technology. The space programme has built synergy in industrial development in the country and built a strong partnership with Indian industries. More than 500 small, medium and large scale Industries participate in the Space programme in the form of engineering hardware development, supply of materials, mechanical fabrication, development of electronics components and software, testing and other services. Almost 60% of the money spent on a launch vehicle flows to Indian Industries. Tele-education and tele-medicine are examples of recently deployed space-based applications where almost 100% of the ground segment equipments and services have been developed by Indian Industries [2].

ISRO has also contributed for capacity building and nurturing the Indian industries through technology transfer, consultancy, funding and infrastructure development. So far, ISRO has developed and transferred about 300 technologies to industries in the fields of electronic and computer based systems, specialty polymer chemicals and materials, electro optical instruments, mechanical equipments and ground systems. Many of the industries have been able to supply products developed using these technologies to users other than the Space Programme. Thus a large sector of general engineering users have benefited from the space programme.

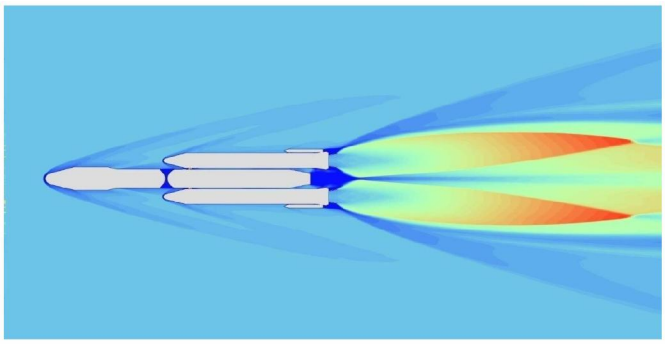
3.0 Technology products

A number of technology and products primarily developed for space programme have also benefited users from other disciplines. These include products realized in mechanical systems, materials, chemicals, electronics, software etc which find use in general applications and for general users.

3.1 PARAS-3D - Parallel aerodynamic simulator software

PARAS 3D is a general purpose flow analysis and simulation software developed by ISRO, is an example in this regard [4]. The features of the software include fully automated grid generation, ability to handle complex geometries, interfaces for CAD geometries, adaptive grid refinement etc. The software runs on computer system named SAGA (Super Computer for Aerospace with GPU Architecture) configured in-house with Linux OS using open source components. The software uses three technologies for high performance computing namely distributed computing, shared memory computing and GPU accelerators. This facility together with PARAS-3D software helps solve Computational Fluid Dynamics (CFD) problems in a very cost effective manner with considerable reduction in execution time. The facility is being successfully applied to a number of complex practical problems in the aerospace domain.

This software is extensively used for aerodynamic design and analysis, to continually refine and improve design prediction capabilities. The software is today being used by other institutions like DRDL, ADA, ADE and IISc in addition to ISRO. The software is implemented in the Space Technology Cell in IISc Bangalore for use of student and research community. The software is being extensively used for design studies by institutions in the strategic sector.



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3.2 GAGAN (GPS-Aided Geo-Augmented Navigation)

GAGAN is an indigenous navigational guide system developed by ISRO in association with AAI (Airports Authority of India) with a view to assist aircraft in accurate landing and take-off even during very poor visibility conditions.

3.3 IRNSS (Indian Regional Navigation Satellite Systems)

To implement India's own navigation system, ISRO is realizing Indian Regional Navigation Satellite System (IRNSS), a constellation of seven satellites of which four are already placed in the orbit. Its area of coverage is the Indian sub-continent and 1500 km beyond Indian boundaries, mostly focusing on SAARC region, with an accuracy of less than 20m. It will provide terrestrial, aerial and marine navigation, support disaster management, vehicle tracking and fleet management, integration with mobile phones, mapping and geodetic data capture.

4.0 Spin-off Products

Technologies developed originally for the Space Programme have found novel applications in totally unconnected fields, with significant benefits to society. A few examples are highlighted in this section [5].

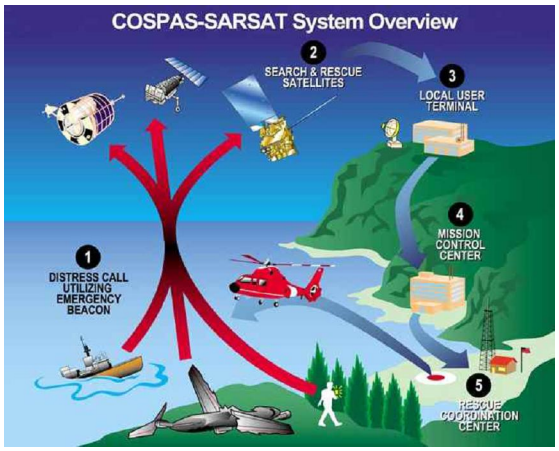
4.1 Artificial Polyurethane foot

Polyurethane (PU) technology was developed using microcellular polyurethane foam for insulation, damping, acoustic protection and other lightweight applications in launch vehicles. The development of PU foams has resulted in an important spin off in the form of artificial foot prosthesis. The PU foot underwent extensive field trials and modifications in collaboration with Government Medical College, Thiruvananthapuram. Subsequently, this was fitted to many amputees successfully. The PU foot developed by ISRO has numerous advantages over the traditional artificial foot. The prostheses are made of variable density microcellular elastomer. It has natural looks, is lightweight, flexible, comfortable, slip resistant and more durable and has leverage, balance etc and is easy to manufacture in

large quantities. The average weight of the foot is about 500 gm. Amputees especially among the poor and needy in the country have benefited from the prostheses replacement.

PU foot

4.2 Search and Rescue Beacon



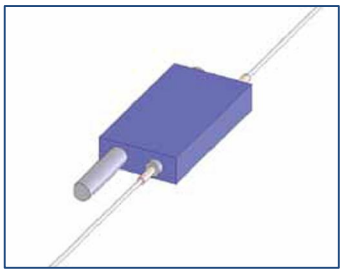
COSPAS-SARSAT System Overview

Technology developed for communication devices for launch vehicles have led to the development of beacon systems deployed in Search and Rescue Systems [3]. A *Search and Rescue Beacon* is an affordable and technically advanced electronic device that helps in locating and rescuing people in distress, by making use of satellite communication. The beacon, carried by the users in distress, transmit encoded digital messages that contains information about the beacon, such as its unique identification number, country where the beacon is registered etc. along with current location of the beacon. The beacon gets location information from Global Positioning System (GPS). Various search and rescue satellites under the international Search and Rescue system called COSPAS-SARSAT network receive the transmitted signals. The messages are processed and retransmitted to different ground stations. These dedicated ground stations receive the message and alert the rescue centres nearest to the spot of user. The rescue centre in turn initiates the rescue operations. The beacon can be used in sea, on difficult terrains on the land and in air.

4.3 Fibre Optic Liquid Level Detector

Cryogenic fluids such as liquid Nitrogen, liquid Oxygen, liquid Hydrogen and liquid Helium find extensive applications in aviation, space technology and scientific research. ISRO at its Liquid Propulsion Systems Centre in collaboration with Indian Institute of Science (IISc) has developed a novel 'Fibre Optic Liquid Level Detector', which finds wide industrial and commercial applications [1]. Fibre optic devices sense the liquid levels typically through principles of reflection/refraction and they facilitate non-invasive level detection at an extremely high speed.

The device is simple in construction, robust in operation, easy to manufacture in large scale and is industrially viable. It is suitable for a variety of fluids and provides very fast responses. Traditional methods have high costs, slow response, heavy weight and have potential "electric spark hazard" which poses questions on their reliability, especially when used in detection of the liquid levels in fuel tanks in aerospace industry.



Fiber optic liquid level detector

The product can be used to detect the liquid level of any transparent fluid. The optical design approach ensures an electrically passive and inherently spark-free sensing operation. In explosive environments, such features help to realize a safe operation with increased efficiency and reduced maintenance loads. Some of the potential areas of use are as follows:

- The device finds application as "Green Monitoring Device", in a variety of areas especially for sensing and controlling the quality and quantity of fuels, thereby contributing towards monitoring for environmental pollution control.
- Handling of petrochemical and chemically harsh liquids during storage and bulk transportation.
- As a "built in device" in tanks of various sizes for detection of quantity of residual fuels in a more accurate manner.
- Reliable monitoring of fluids quantitatively during filling or emptying of tanks at high flow rates.

4.4 Lower Atmospheric Wind Profiling (LAWP) Radar

The Lower Atmospheric Wind Profiling Radar (LAWP) developed by ISRO provides data to study the dynamics of the lower atmosphere (up to 5 km) [1]. A coherent-pulse Doppler-radar, it is one of the most suitable remote sensing instruments for observing height profiles of three components of wind velocity vector, including the vertical velocity, with high time and height resolutions without the influence of weather conditions. The salient features of LAWP include simplified active aperture, solid state transmit receive modules, calibration free passive BFN (Beam forming network), direct IF (Intermediate Frequency) digital receiver, pulse compression, continuous operation capability and easy transportability.

LAWP radar is a potential tool to carry out research studies such as atmospheric boundary layer (ABL) dynamics (winds, turbulence structure), seasonal and inter annual variations, interactions between the ABL and the free troposphere, vertical profiles of precipitation, bright band characterization, monitoring the height of the melting layer and the vertical extent of hydrometeors, raindrop size distribution, etc. Operational field of applications include improved short-range forecasting, numerical weather prediction models, air pollution, civil aviation and flight planning, identification of

LAWP Radar

atmospheric ducts, air pollution prediction, wind shear monitoring, temperature profiling in the radio acoustic sounding system mode etc.

4.5 Silicone polymer based Thermal Protection Systems (TPS)

SSF P70 is a low density Thermal Protection System (TPS) based on silicone polymer, with micro-balloon and other fillers as compounding ingredients [1]. This thermal protection system is room temperature curable and can be applied by brushing and spraying techniques. The remarkable features of this system includes simplified and cost effective process, low density of 0.38 g/cc, lower thermal conductivity and high specific heat. It has flexibility with respect to application procedure such as spraying and brushing, compatibility with wide variety of substrates including metals, composites etc and excellent ageing behaviour, making it suitable for long term application with no deterioration of properties for more than two years. The system can be tailored for use as coating on metal substrates for outdoor use.

4.6 Fire extinguishing powders

One of the widely used ISRO products is fire extinguishing powders - 'OLFEX' for flammable liquid and gas fires and Ternary Eutectic Chloride (TEC) powder for metal fires. OLFEX is a reaction product of urea and potassium bicarbonate and is used for extinguishing oil fires. TEC powder is an effective and efficient dry powder which is suitable for extinguishing fires involving reactive metals like magnesium, sodium, zirconium, aluminum etc. The performance of OLFEX is quite comparable with imported powders for similar applications. This technology exhibits excellent fire knockdown efficiency in addition to superior water repellency, flow characteristics and shelf life. Both these powders have been extensively tested by various competent and independent agencies.

4.7 Silica Cloth

Silica cloth developed by ISRO, named ISROSIL, is being used by industries for insulation and thermal protection for non metallic bellows, wrapping for pipes, cables and hoses, vertical strip furnace curtains, seals and gaskets etc. This environmentally approved asbestos free material provides high thermal, electrical and acoustic protection. This flexible textile product is available in various forms such as fabrics, tapes, sleevings, ropes, threads etc. This has been successfully used as thermal blankets in industries dealing with high temperature and corrosive applications.

4.8 Adhesives

Adhesives developed by ISRO for its own applications include both structural and non-structural adhesives. These adhesives can find varied applications in automobile and other engineering industries. The use of adhesives, for joining, fixing and sealing, in the automobile industry is on the increase mainly due to its inherent advantages. The main advantages are improved stress distribution, weight saving, noise and vibration reduction, corrosion prevention, ease of joining dissimilar materials, sealing of joints, improved stress distribution and aesthetic appearance.

4.9 Doppler Weather Radars

Doppler Weather Radar (DWR) provides precise advance warnings, enhancing the lead time for saving lives and property in the event of natural disaster associated with severe weather. The salient features of DWR providing quantitative information about the intensity and radial velocities of cyclones, area rainfall rate & accumulation, substantially increases the lead time for cyclone warning and remedial measures. These help identify accurately the threatened areas, improves the accuracy of mesoscale rainfall estimates for flash flood warning and improves the understanding and forecasting of thunderstorms, hailstorms, tidal waves, wind turbulence and shear, visualization of storm structure etc

5.0 Support of Space products and services to various other sectors

Space-based applications provide value-addition in many sectors which are not directly connected with the fields of science can technology. A few of these areas are discussed in this section [5].

5.1 Education and infrastructure

Satellite based data and applications support a large range of local services as diverse as customs and border control, city planning, distance learning, disaster relief, search and rescue, biotechnology and health care. Tele-education supports both distance education for students as well as continuing education for professionals. ISRO has supported various student experiments in the area of payloads and satellites. A number of student satellites have been launched on board PSLV. Study of satellite imagery and microgravity research have lead to new discoveries. Studies made towards Space applications have contributed to R&D in fields like bone loss/osteoporosis research, vaccine research, energy research, disease prediction and monitoring, etc.

5.2 Travel and Entertainment

Space products and services play an important role in travel and the entertainment industries, such as direct-to-home television, television content, distribution to hotels, computer reservation services, satellite radio, digital movies, digital content to cell phones and GPS-based services.

5.3 Energy resources and environment management

Remote sensing satellites provide a wide view of earth that enables applications in local and regional levels in the areas of energy resources and environmental management. Weather monitoring and forecasting, resource exploration and exploitation etc are among some of the applications.

5.4 Transportation, logistics and manufacturing

A wide range of industries viz. shipping, airlines and terrestrial public transportation utilize several space technology-based applications in services like air traffic control, inventory control, package tracking, warehouse inventory management, etc.

5.5 Retail, finance and corporate services

This sector includes businesses engaged in sales, financial transactions, manufacturing and other enterprises requiring connections among distributed locations, supported by Satellites. Direct to home

internet, video conferencing, tele-training, e-commerce and video surveillance utilize space-based services.

6.0 Conclusions

Indian Space Programme is continuing in its mission to bring the benefits of space technology to soceity, by embarking upon missions to continue the applications and services already provided as well as embarking upon new missions, both to improve the services as well as to build new applications. Developments in Indian Industry have also occurred with synergy alongside the Space Programme. While the technology and applications developed benefit directly, spin-offs from space technology are also significant. Many products have been developed which find applications in a plethora of fields unconnected with space technology. A few of these products have been looked into here. This is a continuing saga and more and more of such applications are awaited. Thus in direct and indirect manner, the Indian Space Programme touches the lives of the common man in myriad ways.

Acknowledgements

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